# An Evaluation Tool for Extracurricular Activities to Reduce the Gender gap in Computer Science

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**Abstract**: In the last few years, workforce with STEM (Science, Technology, Engineering and Math) competencies has proved to be crucial for countries' innovative capacity and global competitiveness. Yet women are vastly underrepresented in STEM and, in particular, in ICT and computer science fields, both among workers and degree holders: this gap hinders the possibility for ICT employment to be strengthened and for women to take advantage of career opportunities, thus perpetuating gender inequalities in these disciplines. To counteract these effects and attract girls towards ICT-related fields of study and careers, several initiatives have been organised all around the world, such as summer camps and dedicated extracurricular activities. However, these initiatives are usually not supported by proper evaluation tools allowing researchers and practitioners to understand the actual benefits of the carried-out activities on girls' competencies and future attitudes. In this paper, we propose an evaluation tool for extracurricular activities aimed at reducing the gender gap in ICT. The proposed tool aims at capturing both a quantitative and a qualitative evaluation, including an Implicit Association Test (IAT) along with a more traditional questionnaire consisting of thematic sections designed to analyse various aspects of the activities' impact on girls. The tool has been applied in the context of two summer camps related to national and international projects aimed at attracting girls towards computer science and STEM disciplines: the 'Digital Girls' project, organised since 2014 by the University of Modena and Reggio Emilia in collaboration with other universities and local institutions, and the "STEM for Future" Erasmus+ project. Based on the results obtained by the summer camp case studies, we discuss some critical elements that can hinder the efficacy of the evaluation tool, giving suggestions to overcome these potential issues.

**Keywords**: Gender gap, ICT education, Evaluation tool, Extracurricular activities, Implicit Association Test

## 1. Introduction

Recent statistics about European and worldwide conditions indicate that women's presence in computer science professions and related university programs has not significantly improved in the last decade, and women still are severely under-represented in these fields (Eurostat Statistics, 2017-2019). Both literature and real data show that gender differences with respect to interests, sense of belonging, self-confidence and engagement towards STEM and computer science are already in place at an early age (Spieler et al., 2020). Reaching a complete understanding of the reasons for this gender gap is a complex task, but (at least some of) the main motivations appear to be related to social and cultural related issues, such as gender stereotypes in the computer science field (Master, 2021). Stereotypes, in general, influence people and produce misrepresentations: computer science is typically associated with the masculine role, but stereotype misconceptions may also regard physical appearance, personality type and digital ability projected onto young females, negatively influencing their academic decisions and career choices (Berg, 2018).

The European Commission suggests that the gender gap should be addressed by a set of policies that include breaking gender stereotypes by means of awareness-raising campaigns and concrete actions (European Commission, 2018), such as earlier interventions in students' life, including extracurricular activities and training (Davaki, 2018). In the last years, many public and private institutions have undertaken similar actions with the goal of attracting girls towards computer science through activities such as summer camps and dedicated laboratories where the participants are exposed to hands-on experiences about coding and or doing projects. However, these activities typically lack a proper assessment regarding the resulting impacts and effects on the participants. Indeed, the main focus of such programmes is usually more on the implementation of computer science activities and team-based projects rather than on a comprehensive and specifically designed evaluation of the obtained results.

In this paper, we propose an evaluation tool for measuring important aspects related to the impact of extracurricular activities and participants' backgrounds, attitudes and intentions for future choices about studies or careers. The proposed tool includes both qualitative and quantitative measuring methods. Moreover, it leverages the opportunity to evaluate implicit biases that may deeply affect future girls' choices through the Implicit Assessment Test (IAT) method (Schnabel et al., 2008). The evaluation tool has been applied to two extracurricular activities carried out by the University of Modena and Reggio Emilia in the context of national

and international projects. Specifically, we test the tool during the activities of the 'Digital Girls' project (Faenza et al., 2021-2021b) and of the Erasmus+ project "STEM for Future"[1].

The rest of this paper is structured as follows. Section 2 describes the context of the proposal, highlighting the need for a structured tool for an exhaustive evaluation of the extracurricular activities' impacts. Section 3 describes the structure of the proposed evaluation tool, with references to the literature motivating the choices of the tool's main elements. Section 4 presents the case studies to which the tool was applied, presenting a discussion on the main observed critical elements and suggestions to overcome them. Section 5 concludes the paper with some final remarks.

## 2. Literature Review

As stated in (Faenza et al., 2021), many initiatives aimed at reducing the gender gap in the ICT-related field have been carried out in the last decade. Still, these initiatives are usually not supported by proper evaluation tools allowing researchers and practitioners to investigate the eventual benefit of the camp initiatives on participants' competencies and future choices. The main aim of surveys submitted after the extracurricular activities is usually to evaluate the participants' satisfaction. On the other hand, we claim that a structured, specifically designed survey solution is necessary to investigate other meaningful aspects and the real impacts of the camps.

To the best of our knowledge, there are no studies that proposed an evaluation tool that can be directly reused or easily adapted for the extracurricular activities considered in our study. Similarly, no studies provide directions or guidelines for designing and developing such a tool. In some cases, the used survey structure and methodology are provided as an appendix. An example is the case of (Danoff M., 2017), which provides the methodology used to assess gender barriers towards Computer Science at Harvard. However, the study focuses on college students and the survey is tailored to the Harvard faculty context. In other cases, the study's main aim is to give suggestions and guidelines for STEM summer camps without providing adequate information about the assessment phase (Davis et al., 2013; Mohr-Schroeder et al., 2014). Our study aims to fill this gap by describing the structure of the proposed evaluation tool and the methodology followed to design it.

Some studies focus on the analysis of gender gaps in ICT and the identification of the main factors that impact on girls' choices in terms of future studies and careers. The survey in (Spieler et al., 2020) included analyses of 28 peer-reviewed articles on that topic highlighting in particular how different factors can impact the decision to choose a degree course in ICT. They also investigate the self-perception of participants about their capabilities in ICT and the similarities and dissimilarities between their identity and the perceived identity of a ICT expert (Lewis, Anderson & Yasuhara, 2011). Moreover, correlations between video games playing and attitude toward ICT are also studied: (Davies et al., 2014) shows a correlation between students who do not play video games and students who describe their computer skills as poor or do not spend much time on technological devices. Finally, teachers' and parents' influence on participants' aspirations is analysed in (Wong & Kemp, 2018). We took into account these results to design our tool, as described in the next section.

## 3. Research Methodology

In this section, we describe the research methodology that led us to propose the evaluation tool for summer camp initiatives focused on computer science education. The first phase of the methodology includes a literature review, whose results are used as the basis for the tool design.

The purpose of the literature review is to validate and improve the questionnaire design phase. In our case, we focused on studies related to summer camp initiatives on computer science themes whose main participants were female. We found an in-depth study investigating the gender stereotypes in ICT, negative impressions experienced during ICT classes and influences that may prevent girls' interest in this field (Spieler et al., 2020). The study revisioned 28 peer-reviewed articles on the themes and was very helpful in orienting our choice of how to improve the survey design. As a result, we decided to include questions about family support and the ability to identify themself with ICT professionals, besides videogames experience. Another result of this phase was the decision to include focus groups and an Implicit Association Test (IAT from here forward). The IAT test has recently been widely used to assess mental associations (e.g., associations with race, gender, and more) and to predict judgement and behaviour (Greenwald et al., 2009). In particular, other researchers have considered the tool a valid instrument to measure the implicit association of STEM-related and non-STEM-related words

[1] https://www.ifoa.it/servizi/enti-scuole-e-internazionale/progetti-internazionali/stem-for-future/

with female and male names (Farrell et al., 2017; Smeding et al., 2012). To summarise, compared to previous editions' surveys, two classes of improvements were introduced: *technical* and *conceptual* improvements.

Concerning technical improvements, we introduce the possibility of tracing the response evolution. Since our surveys were submitted before and after the camp, some questions were repeated to trace eventual changes in the girls' perceptions. To this aim, we connect answers given by the same participant before and after the camp. Moreover, we wanted to connect some background data collected at the moment of the camp enrolment. The solution was to assign each participant a code to use during the questionnaire submission and then completely anonymise answers during the analysis phase. This allowed us, after the camp, to join answers from the same person and remove the code for anonymization.

Another technical advancement was the adoption of a structured survey system. In the early years of the initiative, tools like Google Forms were mainly employed; however, the solution needed more advanced features like, for example, branching and skip logic for questions, templates, invitations and reminders by email and session-based survey. These needs have led in recent years to the adoption of LimeSurvey, an open-source online survey tool that can also be installed on-premises.

With respect to conceptual improvement, the more innovative choice was to include an IAT test. The main principle behind the IAT test is that self-exploration is subject to introspective limits. The test measures the differential association of 2 target concepts with an attribute: the two concepts appear in a 2-choice task (e.g., flower vs insect names) and the attributes in a 2nd task (e.g., pleasant vs unpleasant words for an evaluation attribute). When instructions oblige highly associated categories (e.g., flower + pleasant) to share a response key, performance is faster than when less associated categories (e.g., insect + pleasant) share a key. This performance difference implicitly measures the different associations of the two concepts with the attribute (Greenwald et al., 1998). As stated by the Harvard online platform Project Implicit (https://implicit.harvard.edu), the IAT measures the strength of associations between concepts (e.g., black people, gay people) and evaluations (e.g., good, bad) or stereotypes (e.g., athletic, clumsy). The participant is asked to categorise terms displayed at the screen's centre as quickly as possible. On the left and right of the screen, two or more categories in opposition to each other are shown (Figure 1). The main idea is that categorising a term is more straightforward when closely related categories are displayed on the same side of the screen.

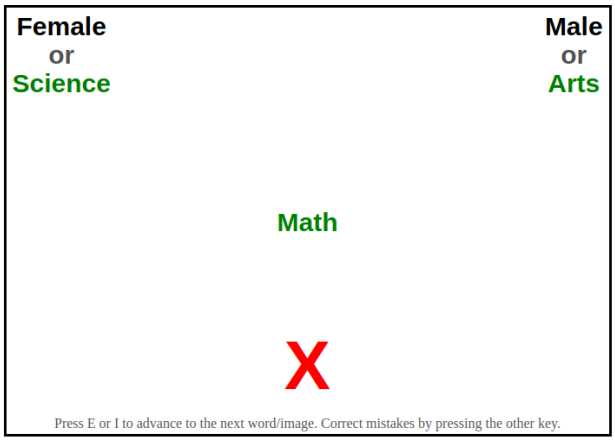


**Figure 1: Screen of an IAT Test Being Employed**

Including the IAT test led to the less obvious matter of choosing an instrument to operate online. The LimeSurvey tool used in previous years did not allow the inclusion or the development of an IAT test. Hence, our choice was to migrate to a more complex platform, Qualtrics. The availability of an open repository, IATGEN (Carpenter et al.,2019), to develop an IAT test integrable inside Qualtrics' surveys led to this choice. IATGEN is an open-source tool written in R that can generate an IAT test as a survey element composed of HTML and Javascript; it also offers a suite of data analysis tools for processing the resulting data.

Another conceptual improvement concerns the choice to exploit focus groups with the final aim of selecting the most appropriate questions and validate our hypothesised survey structure. Focus groups, indeed, help investigate matters that are difficult to investigate throughout a survey. For example, it is possible to investigate if widespread descriptive stereotypes about women (Heilman, 2001) influence participants' perceptions about their studies and career opportunities. Focus groups are usually held with a group of four to six people and require the presence of an expert researcher, able to properly moderate and lead the discussion.

## 4. Proposed Evaluation Tool

In this section, we describe the proposed evaluation tool, specifically designed to evaluate the impact of extracurricular computer science camps on female participants. The evaluation tool comprises a series of focus groups and an online questionnaire, which includes two main parts: an initial IAT test and the main survey. The main survey includes questions that can be categorised into five main categories: background information, computer science perception, future choices, gender stereotypes and camp satisfaction.

### 4.1 Focus Groups

As planned, we decided to employ focus groups to validate our main survey section. We opened a call with participants from the previous editions of the 'Digital Girls' camp and selected 15 of them, of which five decided to continue their studies in ICT curricula. Moreover, we selected five girls from the ICT course who had no opportunities to participate in any ICT camp initiative during high school. We created four sessions with five participants to maximise the effectiveness of the focus groups. For logistic reasons, three sessions were held using a Web meeting platform. The expert researcher who led the focus groups explained that video conferences were the most appropriate way to conduct focus groups during the pandemic.

Finally, we defined the stimuli to be used during each session. They consisted of four main questions and phrases, each with two to three sub-stimuli to be deeper elaborated in case of stalled conversation. Moreover, stimuli were slightly different for those who did not attend any ICT camp initiative before they chose to enrol in an ICT degree. Specifically:

- let us reflect on the moment in which you chose to enrol in ['Digital Girl' summer camp | Computer Science degree]
- explain what your drives were
- describe what you expected to find
- describe what you found
- what was your idea about the "ICT world" prior to this moment
- explain how this idea formed
- describe your experience with the "ICT world" prior
- describe if and how enrolling to [camp | degree] changed your idea
- (if camp participant) describe if and how attending the camp modified your future choice
- (if ICT degree student) describe your possible future work and your ambition in the field
- identify four keywords to describe your experience with the ICT world until today

Focus group results typically require a long time to be analysed and a specialised researcher's expertise. However, a few notes from the live sessions have helped us find new essential aspects to investigate. For example, during sessions, the presence of a parent passionate about anything related to computer science or electronics was noticed for almost all students attending ICT courses. Hence, we decided to include a couple of questions in the survey to investigate if the presence of such a figure could lead to a higher probability of considering ICT as a possible field of study.

### 4.2 IAT

As previously stated, we decided to include an IAT test in our surveys. The preparation stage of an IAT test requires selecting two categories of opposing concepts; then, words strongly related to each concept must be selected. In our case, we selected as target categories the couples "Science"-"Arts" and "Male"-"Female". The idea was to test if there is a positive correlation between them, hence less time for categorising words when the "Male" and the "Science" categories are on the same side of the screen. The objective was to employ the test before and after the camp to understand if camp activities could lead to a change in implicit associations. More in detail, the chosen categories with stimuli were:

- Science: Maths, Physics, Chemistry, Statistics, Computer Science, Engineering, Mechanics, Electronics
- Arts: Art, History, Philosophy, Literature, Music, Teather, Language
- Male: Male, Man, He, Husband, Father, Uncle, Grandfather
- Female: Female, Woman, She, Wife, Mother, Aunt, Grandmother

An essential part of a successful IAT test is to use the mother language of the participants. In fact, for the use in the StemForFuture Erasmus+ project, a phase of translation in the mother tongue of each country participating in the initiative was undertaken.

Since each IAT test requires more or less 10 minutes to be completed, it was not possible to test more implicit associations, for example, an association between male/female and career/family; hence we chose to investigate other aspects using multiple-choice questions and free text answers.

### 4.3 Survey Structure

The final result consisted of two surveys, one submitted at the beginning and one at the end of the camp activities. Some questions were repeated both before and after the camp in order to grasp the eventual change in the knowledge, perceptions and attitudes of participants after the experience. A list of question categories is presented in the rest of this section in order to better understand the proposed survey structure.

#### *4.3.1 Personal background*

The first category of questions is related to participants' background; since obviously there is no need to ask again at the end of the camp for the same, these pieces of information can also be collected at the moment of participant enrolment, provided that anonymity must be guaranteed. Questions of this category regard general information such as nationality, attending school address, place of birth and age but also more specific information:

- parents' employment;
- if and how parents are involved in or passionate about CS or electronics;
- if the participant regularly plays video games and which one in particular.

It is part of the personal background, questions about the eventuality they have already coded before, and more in-depth questions about their experience with coding.

#### *4.3.2 Computer science perception*

As a consequence of what we learned from the literature review (section 3.2), we decided to include questions in order to understand participants' beliefs about ICT professionals before and after the camp. In particular, we asked them to choose a few adjectives to describe an ICT professional and then a few adjectives to describe themself, with the aim of comparing the result before and after the camp and analysing how those descriptions evolve. Also, before the camp, we asked what their idea was about the "ICT world" and how much they knew about it, while after the camp, we asked if their perception of the same has changed and, if so, how.

#### *4.3.3 Future choice*

An essential section of our surveys is dedicated to participants' future choices. It is repeated before and after the camp initiative to understand better if the camp impacted participants' ideas. We ask participants whether they are willing to continue studying or to look for a job and which will be their field of study or occupation. Then, in the final survey, we ask if their idea has changed and why; in the initial survey, we ask them if they talked about the possible choices with parents or teachers and, eventually, what their opinion is.

#### *4.3.4 Gender stereotypes*

An entire section is dedicated to gender stereotypes; here, the aim is to understand if the participant believes or not if being a woman or having a family could pose an obstacle for the future choice or for having a career in ICT and non-ICT fields. Also, these questions were submitted before and after the camp since, over the years, we noticed that a major awareness about stereotypes in the study and work field has arisen.

#### *4.3.5 Camp satisfaction*

A final section submitted only at the after-camp survey analyses camp satisfaction in terms of general satisfaction and specific likings of single aspects of the camp, like activities employed, teamwork, teachers and more. Furthermore, we ask participants to highlight the best and worst part of the experience and to suggest possible improvements.

## 5. Case Study

The proposed evaluation tool has been applied in the context of two extracurricular activities dedicated to STEM disciplines. The first one is the project ‘Digital Girls’, an initiative dedicated to female students of third and fourth-grade high schools to attract girls towards ICT and computer science. The evaluation tool has been applied to evaluate the impact on almost 200 girls aged 16-18 during the 2022 edition of the Digital Girls summer camps, which were carried out in six cities in the Emilia Romagna region.

The second case study for the application of the evaluation tool is the STEM for Future Erasmus+ project, which aims to develop increased knowledge and culture about STEM disciplines and professional opportunities among students of high schools. The project activities include designing and organising four national summer camps in the partners' countries (Italy, Portugal, Spain and Estonia) in 2022 and one international camp in 2023. Among the project, an objective is developing an assessment methodology that recognises knowledge and skills acquired through the camp activities and measuring the impact on participants. The evaluation tool has been applied in the context of the 2022 national summer camps on almost 80 students aged 16-18.

### 5.1 Critical Observations

During the survey submission phase, a critical element is the compilation time, the global time needed to answer questions and the lAT test. A too-long survey tends to tire the participants: we noticed that the accuracy and the exhaustiveness of the answers given to the last questions of the survey dramatically dropped. Also, in some cases, free-text answers were utterly absent or substituted by hyphens, commas and points. This could be a consequence of the excessive survey duration or possibly of a failure to make participants understand the importance of their answers for research purposes. Using software tools to detect inconsistent and invalid answers could be extremely useful in these cases. Moreover, limiting free-text questions or placing the same at the start of the survey could lead to better results.

Another observation comes from the IAT test's presence: including it at the beginning of the survey extended the compilation time by about 10 minutes, thus leading to quite long global compilation times. A possible solution to this problem could be submitting the IAT test at a different moment. For example, at the end of the first day of activities or at the beginning of the second day. Indeed, while for most questions of the initial survey, it is essential to avoid any potential influence given by the information received during the camp activities, the time needed to measure a change in an implicit association is much longer. Hence, there is no urge to submit it at the very beginning of the camp.

Another important lesson we learned is the importance of testing the survey with a group of people having characteristics similar to the target population. In our case, we tested the surveys with 20 girls aged 16-18. Even if we had experts designing the survey and refining the final questions, some had to be corrected to be adjusted to the target because they resulted as unclear or ambiguous. For example, we submitted a question asking teachers' opinions about students' future study choices. Some students observed that they never discussed their choices with teachers, so we changed the question to include that as a possibility.

Finally, even if the collected data were anonymised, we could connect answers from the same person to the initial and final surveys.

### 5.2 Example of Results

For space reasons, we do not present here all the results obtained through the proposed evaluation tool. However, we describe an example of analysis that shows the need to connect the answers provided before and after the camp. Specifically, we show the results from the Digital Girls camp about the future study choices of the participants. Several questions were included in the survey to this aim. In particular, we asked participants, '*Do you plan to keep studying?*' and, in case of a positive answer, in which possible fields. In the analysis phase, we grouped participants' answers to create a dummy variable answering the direct question '*Do you plan to continue your studies in the ICT field?*', hereafter referred to as the *target question*.

The previously cited 'Digital Girls' camp took place in six different cities of the Emilia-Romagna region in Italy. For the scope of this simple analysis, we will consider answers from two cities. Figure 2 shows the answers to the target question for the two cities, named *City A* and *City* B. In the left part of the figure, we see the *target question* number and percentage of answers before the camp, while in the right part the answers after the camp.

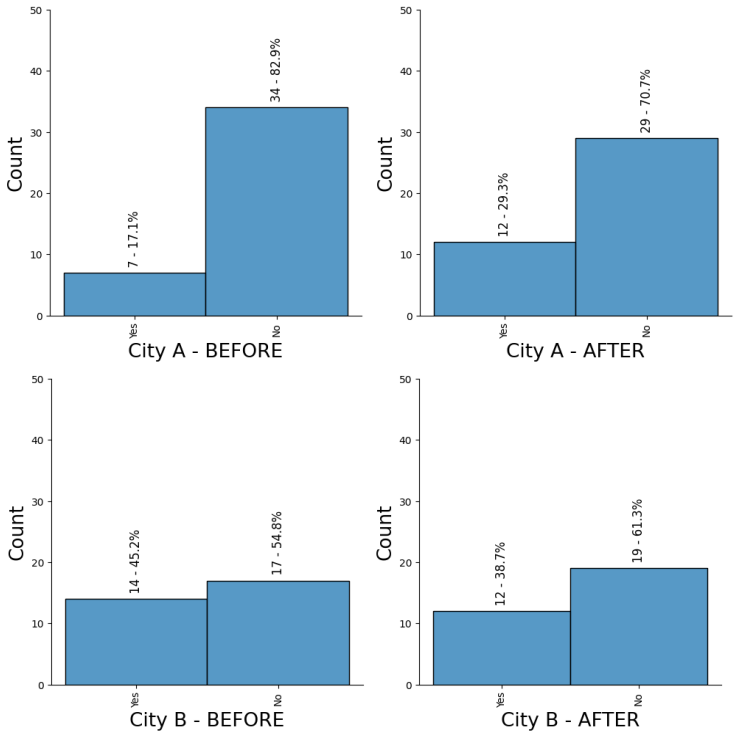


**Figure 2: Results to *Target Question* Before and After the Camp For *City A* and *City B***

Analysing *City A* results, we see that five participants changed their answers from '*No*' to '*Yes*', and, given the camp's aim, this is a positive result since it means that 5 participants decided to include ICT fields in their possibilities for future studies. Instead, *City B* has an apparently negative result since 2 participants changed their answers from '*Yes*' to '*No*'.

In the absence of a connection between answers before and after camp, the only conclusion from this analysis is that City B's performance is much worse than city A's. Nevertheless, we can perform an in-depth comparison of the participants' opinions thanks to the connection between before and after results. In particular, we divided after camp answers into two groups: participants who answered '*No*' and participants who answered '*Yes*' to the *target question* before the camp.

Figure 3 shows the in-depth results for *City A* and *City B*. In the left part, Figure 3 shows results after the camp for *City A* and *City B* (as in Figure 2). In the middle part of the figure, the two graphs exhibit the answers of participants who chose '*No*' before the camp. On the right side, the answers of those who chose '*Yes*' before the camp are displayed.

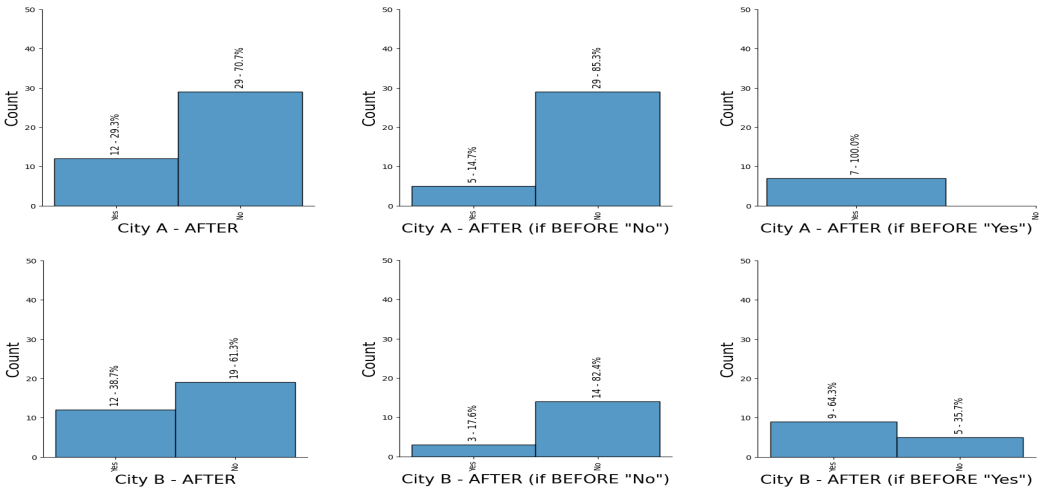


**Figure 3: Results to Target Question Before and After With**

This analysis confirms that in *City A* 5 participants changed their minds from '*No*' to '*Yes*'. Moreover, in City A, all the participants who answered '*Yes*' before camp confirmed their choice. In the case of *City B*, 3 participants changed their minds and chose ICT after the camp. Interestingly, the percentage of participants changing their minds is almost the same (14.7% *City A*, 17.6% *City B*). However, in the case of *City B*, 5 participants who previously were interested in continuing their study in ICT said '*No*' to the question after camp. To better understand the motivations behind the changes, we investigated the free-text answers given by the respondents. For example, the question '*If you changed your mind, please explain why*' shows answers like '*I thought that ICT was only for geeky people*' or '*ICT is more fun than I thought*' among those who changed their choice positively. In particular, in the case of negative change, the free-text question shows answers like '*I understood that I do not like ICT* and '*Before, I only used ICT as a passive user and I thought it was something different*'. It is worth noting that this should be considered a positive result in terms of study orientation. In fact, 8 participants of *City B's* camp now have a better idea of what to study in the future, eventually avoiding a dropout during academic studies.

This is just an example of possible meaningful insights that may be extracted by a well-designed evaluation tool.

## 6. Conclusions and Future Works

In this paper, we proposed an evaluation tool for measuring the impact of extracurricular activities aimed at attracting girls towards ICT fields. This work represents the initial step of a research line where the first proposal of the evaluation tool is described in terms of structure and design choices. The tool was tested in the context of two case studies, that are two summer camps belonging to a national and an international project carried out during the summer of 2022. To summarise, the main contributions of the paper are: the description of the research methodology that led to the design of the evaluation tool; the description of the evaluation tool structure that can be followed as a high-level guideline for replication in other camps; identification and discussion about some critical elements emerged by the evaluation tool application, along with suggestions to overcome these issues.

In future work, we plan to further improve the tool to obtain a complete instrument that can be released, along with guidelines, and easily adapted to be used in the evaluation of extracurricular activities to reduce the gender gap in ICT and STEM. First of all, we aim to experiment with a version of the questionnaires where the questions appear in a randomised order. In our survey, the questions, as stated, were grouped by category, so testing the usual survey and a randomised version could create an interesting A/B testing situation to verify possible accuracy improvements. Another future plan is to exploit the use of focus groups with participants after they answer the evaluation tool questions in order to capture their perception of potential critical elements that may be improved.

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